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Effect of Simulated Drought Stress on some Grain Shape and Quality Traits of Rice (*Oryza sativa* L.)

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ABSTRACT

Grain shape quality traits of twenty (20) rice genotypes were studied in order to understand the effects of drought stress on quality traits of rice. The result of Analysis of Variance clearly indicates that genotypes significantly differ for studied grain quality traits under both for normal as well as drought prone environments, except grain breadth /thickness without bran under stress condition. Higher heritability estimates for all quality traits under both environments indicate that these characters are controlled by multiple genes. Results showed that grain length was positively correlated with length to width ratio (0.863* and 0.668*) and negatively correlated with grain width (-0.614** and -0.313**) and grain breadth (-0.321**and -0.030^{ns}) under both normal and stress conditions respectively. Grain width was positively correlated with grain breadth (0.711** and 0.486**) and negatively correlated with length to width ratio (-0.926* and -0.910*) under both conditions respectively. Grain width was highly correlated with yield per plant (0.386** and 0.315**) under both, normal and drought stress respectively. It shows that reduction in grain width has direct effect on grain yield. Under normal condition, yield was positively correlated with grain width (0.386**) and grain breadth (0.552*) indicating that grain width and grain breadth should be considered while screening high yielding genotypes under normal condition and grain width should be considered for drought stres

Introduction

Drought is the meteorological event, which implies absence of rainfall for a period of time, long enough to cause moisture depletion in soil and water deficit with a decrease of water potential in plant tissues (Kramer 1980). A definition of drought generally accepted by plant breeders is: "a shortfall of water availability sufficient to cause loss in yield", or "a period of no rainfall or irrigation that affects crop growth" (Price 2002, Fukai and Cooper 1995). Using a similar definition, it has been estimated that 25% of the fields used for upland crop production (Kasuka et al. 2005) are prone to yield reductions as a consequence of drought. Drought therefore has a major impact on world agriculture.

Although rice is consumed worldwide, therefore is no universal rice quality attribute (Veronic et al., 2007). Nevertheless, rice appearance and cooked rice texture are the characters considered as main quality attributes by consumers (Okabe 1979, Rousset et al. 1999). Thus, measuring and understanding factors that influence appearance and texture properties are a great challenge for industries and breeders in meeting consumer preferences. About 13% of the world's 147 million ha of rice is cultivated as rain fed rice under upland conditions (Crosson 1995) where moisture stress affects rice growth and reduces grain yield and quality (Carlos et al. 2008). Water is a major constituent of plant tissue as reagent for chemical reactions and solvent for translocation of metabolites and minerals as well as an essential component for cell enlargement through increasing turgor pressure (Carlos et al. 2008). The occurrence of soil moisture stress affects many of the physiological processes such as photosynthesis and transpiration resulting in poor grain filling and poor quality (Samonte et al. 2001).

Incorporation of preferred grain quality features has become important objective in rice improvement programs next to enhancement in yield. Therefore, it is very crucial to identify how quality is affected when rice crop is under drought stress.

Genetic correlation provides the information about type of relationship of traits among themselves as well as with yield (Known and Torrie 1964). Path analysis furnishes information of influence of each trait to yield under drought stress directly as well as indirectly and also enables the breeders to rank the genetic attributes according to their contribution (Dewey and Lu 1959).

Materials and Methods

In the present research work, twenty rice genotypes were studied for morphological traits during the summer of 2009. Plants were grown in vicinity of University of Agriculture Faisalabad, Pakistan.

The nursery was sown on 29 may, 2009 and transplanted to the earthen pots after 25 days. Two seedlings of each variety were transplanted into one pot, with the distance of 16.5 cm between the plants within a pot. The experiment was conducted in two water regimes: fully irrigated (control) and simulated water stress condition under a randomized complete block design. Both the treatments were replicated three times. All lines were tested under control (with normal irrigation) and drought stress (by stopping irrigation) condition respectively. While P and K were applied in full dose at the time of sowing, N was applied in four splits as top dressing. Insect and weed control measures were applied periodically as required.

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For stress treatment, two consecutive drying cycles were imposed in order to prevent the plants from dying completely and make most of the lines experience drought stress, first round was well before flowering and second one at reproductive stage when plants had started panicle initiation. Stress was realized by stopping irrigation and keeping off rainfall using the shelter. After drought stress, normal irrigation was followed throughout the late stages of rice.

Analysis of variance was conducted for all the traits following Steel et al., 1997. Heritability and Genetic advance was estimated for all traits using the formula given by Falconer and Mackey, 1996. Genetic advance was computed at 20% selection intensity (*i* = 1.4) following Poehlmam and Sleper, 1995.

The genotypic and phenotypic correlation coefficient estimates were carried out using the formula given by Known and Torrie, 1964. Genotypic estimates were used in path coefficient analysis (using formula given by Dewey and Lu 1959) in order to determine direct and indirect effects of traits on yield under simulated drought stress condition. Yield per plant was considered as the resultant variables and others as causal variables. Statistical significance of phenotypic environmental correlation was determined by using t-test as described by Steel et al. 1997.

Observation regarding paddy and seed length, width and thickness were recorded with the help of digital caliper on ten randomly selected three times of full healthy grain.

Results And Discussion

The results of Analysis of Variance clearly indicate that genotypes significantly for grain quality traits under both normal as well as drought prone environments, except grain breadth /thickness without bran under stress condition (Rasheed et al. 2002), that emphasizes that grain length, breadth and width of the genotypes have genetic variability that can be exploited in breeding program (table 5 and 6). Mean values for grain quality traits with and without bran under normal and drought stress conditions are presented in table 5 and 6 respectively. Mean grain lengths with bran under normal and drought condition are 9.55 and 9.057 mm, means of grain widths are 2.238 and 2.011 mm and that of grain breadths are 1.607 and 1.77 mm respectively. Likewise, mean grain lengths without bran under normal and drought condition are 7.33 and 6.818 mm, that of grain widths are 1.959 and 1.840 mm and that of grain breadths are 1.505 and 1.607 mm respectively. The results indicate that grain lengths and grain widths were reduced due to drought stress and grain breadth was slightly increased on average in almost al the observed genotypes.

The results in tables 7 and 8 show that the phenotypic coefficients of variability of all the genotypes were higher than its respective genotypic coefficient of variability for all grain quality traits under both environments, indicating the effects of environment constitute the major portion of the total phenotypic variation. Under normal conditions, there was a slight difference in PCV and GCV for grain length with ban (5.132 and 4.952). Grain length without bran (5.974 and 5.614), grain breadth (4.851 and 4.307) and grain width (8.103 and 7.634) without bran respectively indicating that these traits had less environmental effects as compared to the traits that have greater difference in PCV and GCV values i.e. grain width (9.445 and 7.771) and length width ratio (12.389 and 10.652) with bran respectively (table 7 and 8).

Higher broad sense heritability estimates for all grain shape quality traits under both environments indicate that these characters can be exploited more efficiently through selection in further generations (table 7 and 8) (Rasheed et al. 2002). Estimates for genetic advance for length width ratio and length of the grain were higher as compared to others under normal condition (table 7 and 8).

Table 1: Estimates of genotypic (above) and phenotypic (below) correlation coefficients for grain quality traits with bran under normal condition

Characters	GW	GB	L/W	Y/P	Y/P*
GL	-0.614** -0.563**	-0.321** -0.259**	0.863* 0.840*	-0.367^{ns} -0.318	-0.121^{ns} -0.094
GW		0.711** 0.638**	-0.926* -0.916*	0.386** 0.363**	-0.165^{ns} -0.180
GB		-0.586** -0.520**	0.552* 0.455**	-0.309** -0.265**	
L/W				-0.402** -0.368**	0.042^{ns} 0.068

GL = grain length, GW = grain width, GB = grain breadth, L/W = grain length to grain width ratio, Y/P* = yield per plant under simulated drought stress condition, Y/P = yield per plant under normal condition

Table 2: Estimates of genotypic (above) and phenotypic (below) correlation coefficients for grain quality traits with bran under simulated drought stress condition

Characters	*GW*	*GB*	*L/W*	*Y/P*
GL	-0.313** -0.243**	-0.030^{ns} -0.010	0.668* 0.650*	0.027^{ns} -0.020
GW		0.486** 0.475**	-0.910* -0.886*	0.315** 0.297**
GB			-0.404* -0.380*	-0.042^{ns} -0.030
L/W				-0.265^{ns} -0.263

GL = grain length, GW = grain width, GB = grain breadth, L/W = grain length to grain width ratio, Y/P* = yield per plant under simulated drought stress condition, Y/P = yield per plant under normal condition

Results showed that grain length was positively correlated with length to width ratio and negatively correlated with grain width and grain breadth under both normal and simulated drought stress conditions. Grain width was positively correlated with grain breadth and negatively correlated with length to width ratio under both normal and simulated drought stress conditions. Grain width was highly correlated with yield per plant under drought stress that shows that reduction in grain width has direct effect on grain yield. Under normal condition, yield was positively correlated with grain width and grain breadth (table 1and 2) indicating that grain width and grain breadth should be considered while screening high yielding genotypes under normal condition and grain width should be considered while screening high yielding genotypes under drought stress.

Under normal condition, direct effect of grain length on yield per plant was negative and high, while indirect effects via grain breadth; length to width ratio was positive and high and via grain width was negative and pronounced. Direct effect of grain width on yield per plant was positive and high, while indirect effects via grain breadth; length to width ratio was positive and high, via grain width was negative and pronounced and via grain length was positive and pronounced. Direct effect of grain breadth on yield per plant was negative and high, while indirect effects via grain length; width was positive and high and via length to width ratio was negative but negligible. Direct effect of length to width on yield per plant was positive and high, while indirect effects via grain length; width was negative and high and via grain breadth was positive but negligible (table 3 and 4).

Table 3: Estimates of direct (Bold figures) and indirect effects (Vertically arranged) of grain quality traits on yield under normal condition

Characters	*GL*	*GW*	*GB*	*L/W*
GL	-0.886	0.432	0.426	-0.657
GW	-0.352	0.721	0.437	-0.678
GB	0.519	0.653	-1.079	0.059
L/W	0.722	-0.915	-0.054	0.974

GL = grain length, GW = grain width, GB = grain breadth, L/W = grain length to grain width ratio

Table 4: Estimates of direct (Bold figures) and indirect effects (Vertically arranged) of grain quality traits on yield under simulated drought stress condition

Characters	*GL*	*GW*	*GB*	*L/W*
GL	1.887	-0.590	-0.057	1.261
GW	0.820	-2.563	-1.246	2.332
GB	0.011	-0.173	-0.357	0.144
L/W	-2.673	3.641	1.617	-4.002

GL = grain length, GW = grain width, GB = grain breadth, L/W = grain length to grain width ratio

Under simulated drought stress conditions, direct effect of grain length on yield per plant was positive and high, while indirect effects via length to width ratio was negative and high and via grain width was positive and pronounced. Direct effect of grain width on yield per plant was negative and high, while indirect effects via grain breadth; grain length was negative and high, via length to width ratio was positive and very high. Direct effect of grain breadth on yield per plant was negative but not pronounced, while indirect effects via grain length was negative and negligible, via length to width ratio was positive and pronounced and via grain width was negative and high. Direct effect of length to width on yield per plant was negative and very high, while indirect effects via grain length; width was positive and high and via grain length to width ratio was positive but negligible (table 3and 4).

References

Anonymous. 2008-2009. Economic survey of Pakistan. Finance Division, Economic Advisor Wing, Islamabad.

Balan A, AR Muthiah and SNMR Boopalthi. 2000. Genetic variability, correlation and path coefficient analysis in upland early rice genotypes. J Asian Res. 3: 87-93

Bhatt GM. 1973. Significance of path coefficient analysis in determining nature of character association. J Euphhytica. 22: 338-343

Boojung H and S Fukai. 1996. Effects of soil water deficit at different growth stage on rice growth and yield under upland conditions. J Field Crop Res. 48: 47-55

Carlos ACC, Orivaldo A, Rogerio PS and Gustavo PM. 2008. Grain quality of upland rice cultivars in response to cropping systems in the Brazilian tropical savanna Sci Agric (Piracicaba Braz). 65 (5): 468-473

Crosson P. 1995. National Resource and environmental Consequences of rice Production. In: IRRI Fragile Lives In fragile Ecosystems. Proceeding of the International Rice Research Conference, 13-17 Feb. 1995. PO Box 933 Manila Philippines. 83-100 p.

Dang QN, Soe T, Naoki M, Tran DX, Nguyen, HH and Toshihiro M. 2006. Evaluation of root penetrating ability in rice using wax layers and the soil cake methods. J Fac Agric. 51 (2): 251-256

Dewey DR and KH Lu. 1959. A correlation and path coefficient analysis of components of crested wheat grass and seed production. Agron J. 51: 515 – 517

Dey MM and HK Upadhyaya. 1996. Yield Loss due to Drought, Cold and Submergence Tolerance. J Rice Res Asia. 5: 63-66

Falconer DS and TSC Mackey. 1996. Introduction to Quantitative Genetics, Ed 4. Longmans Green, Harlow, Essex, UK. Fonseca M and L Patterson. 1958. Yield components heritability and interrelationship in winter wheat (*T. aestivum* L.). J Crop Sci. 8: 614-617

Fukai S and M Cooper. 1995. Development of drought-resistant cultivars using physio-morphological traits in rice. J Field Crops Res. 40: 67-86.

Ivanovic M and K Rosie. 1985. Path coefficient analysis for three stalk traits and grain yield in maize (*Zea mays* L.) Maydica. 30: 233-239

Kanbar A and H Eshasiscdar. 2004. Correlation and path analysis for root morphological traits in Indica population of rice (*Oryza sativa* L.). J Crop Res Hisan. 22 (0): 94-98

Kang MS, MD Muller and PYP Tai. 1983. Genetic and phenotypic path analysis and heritability in sugarcane. Crop Sci. 23: 643-647

Known SH and JH Torrie. 1964. Heritability and interrelationship among traits of two soybean populations. Crop Sci. 4: 196-198

Kramer PJ. 1980. Linking Research to Crop Production. Press New York. 51-62.

Kasuka M, AG Lalusin and T Fujimura. 2005. The maintenance of growth and turgor in pearl millet (Pennisetium glaucum [L.] Leeke) cultivars with different root structures and osmo-regulation under drought stress. J Pl Sci. 168: 1-14.

Okabe M. 1979. Texture measurement of cooked rice and its relationship to the eating quality. J Texture Studies. 10: 131 - 152.

Pandey JP and JH Torrie. 1964. Path coefficient analysis of seed yield components in soybeans (*Glicine max* L. Merr). Crop Sci 505 – 507

Pantuwan G, S Fukai, M Cooper, S Rajatasereekul and JCO Toole. 2002. Yield response of rice (*Oryza sativa* L.) genotypes to different types of drought under rain fed lowlands. Plant factors contributing to drought resistance. J Field Crops Res. 73: 181- 200.

Poehlman JM and DA Sleper. 1995. Breeding Field Crops. Iowa State Press Ames Iowa USA. 278-299 p.

Price AH, EM Young and AD Tomos. 2002. Linking drought-resistance mechanisms to drought avoidance in upland rice using a QTL approach. J Exp Bot. 53: 989-1004.

Rasheed MS, HA Sadaqat and M Babar. 2002. Interrelation among grain quality traits of rice. Asian J Pl Sci. 1 (3): 245-247

Rousset S, Pons B and Martin JN. 1999. Identifying objective characteristics that product clusters produced by sensory attributes in cooked rice. J Texture Stud. 30: 50-532.

Samonte S, Wilson LT, McClung AM, Tarpley L. 2001. Seasonal dynamics of non-structural carbohydrate in 15 diverse rice genotypes. Crop Sci. 41: 902-909.

Steel RGD, JH Torrie and DA Dickey. 1997. Principles and Procedures for Statistics. Mc Graw Hill Book Co New York USA. 4 (3): 341-343

Veronic V, Brigitte P, Judith B, Stephan H, Xavier R Christian M. 2007. Cooking behavior of rice in Relation to Kernel Physicochemical Properties. J Agric Food Chem. 55: 336-346.

Wright S. 1921. Correlation and causation. J Agric Res. 20: 557-585

Yang YH, MJ Callow and TP Speed. 2002. Phenotypic diversity and association of some potentially drought responsive characters in rice. J Crop Sci. 31: 1484-1491

Yue B, L Xiong, W Xue, Y Xing, L Luo and C Xu. 2005. Genetic analysis for drought resistance of rice at reproductive stage in field with different type of soil. Theor Appl Genet. 112-113 p.